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ABSTRACT

Crustal Evolution Education Project (CEEP) modules were designed to: (1) provide students with the methods and results of continuing investigations into the composition, history, and processes of the earth's crust and the application of this knowledge to man's activities and (2) to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift, and plate tectonics. Each module consists of two booklets: a teacher's guide and student investigation. The teacher's guide contains all of the information present in the student investigation booklet as well as: (1) a general introduction; (2) prerequisite student background; (3) objectives; (4) list of required materials; (5) background information; (6) suggested approach; (7) procedure, including number of 45-minute class periods required; (8) summary questions (with answers); (9) extension activities; and (10) list of references. Objectives of this 1-2 period module include identifying divergent, convergent, and transform plate boundaries, demonstrating the relationship between plate boundaries on a sphere by rotation of a small piece of the sphere, and determining where earthquakes commonly occur along plate boundaries. (Author/JN)

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CRUSTAL EVOLUTION EDUCATION PROJECT

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Introduction To Lithospheric Plate Boundaries

TEACHER'S GUIDE

Catalog No. 34W1016

For use with Student Investigation 34W1116
Class time: One to two 45-minute periods

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Produced and Distributed by
Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

NAGT Crustal Evolution Education Project

Edward C. Stoever, Jr., Project Director

Welcome to the exciting world of current research into the composition, history and processes of the earth's crust and the application of this knowledge to man's activities. The earth sciences are currently experiencing a dramatic revolution in our understanding of the way in which the earth works. CEEP modules are designed to bring into the classroom the methods and results of these continuing investigations. The Crustal Evolution Education Project began work in 1974 under the auspices of the National Association of Geology Teachers. CEEP materials have been developed by teams of science educators, classroom teachers, and scientists. Prior to publication, the materials were field tested by more than 200 teachers and over 12,000 students.

Current crustal evolution research is a breaking story that students are living through today. Teachers and students alike have a unique opportunity through CEEP modules to share in the unfolding of these educationally important and exciting advances. CEEP modules are designed to provide students with appealing firsthand investigative experiences with concepts which are at or close to the frontiers of scientific inquiry into plate tectonics. Furthermore, the CEEP modules are designed to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift and plate tectonics.

We know that you will enjoy using CEEP modules in your classroom. Read on, and be prepared to experience a renewed enthusiasm for teaching as you learn more about the living earth in this and other CEEP modules.

About CEEP Modules...

Most CEEP modules consist of two booklets: a Teacher's Guide and a Student Investigation. The Teacher's Guide contains all the information and illustrations in the Student Investigation, plus sections printed in color, intended only for the teacher, as well as answers to the questions that are included in the Student Investigation. In some modules, there are illustrations that appear only in the Teacher's Guide, and these are designated by figure letters instead of the number sequence used in the Student Investigation.

For some modules, maps, rulers and other common classroom materials are needed, and in varying quantities according to the method of presentation. Read over the module before scheduling its use in class and refer to the list of MATERIALS in the module.

Each module is individual and self-contained in content, but some are divided into two or more parts for convenience. The recommended length of time for each module is indicated. Some modules require prerequisite knowledge of some aspects of basic earth science; this is noted in the Teacher's Guide.

The material was prepared with the support of National Science Foundation Grant Nos. SED 75-20151, SED 77-08539, and SED 78-25104. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of NSF.

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Introduction To Lithospheric Plate Boundaries

INTRODUCTION

In this module the student studies the three types of lithospheric plate boundaries. Students use a simple spherical model to examine the plate boundaries.

The earth's **lithosphere** is composed of semi-rigid **plates** that move in different directions. A great deal of action takes place along boundaries between plates. Most earthquakes are located there. Figure 1 shows the relation of these plates and the outer shells of the earth.

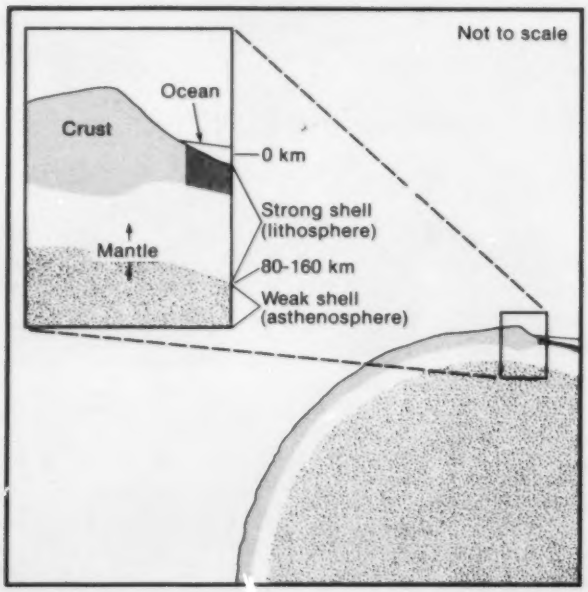


Figure 1. Diagram showing the rigid lithospheric plates and their relationship to the outer shells of the earth (not to scale).

Plates move away from each other along a **divergent plate boundary.** As the plates move apart, material from the **asthenosphere** fills the gap. This creates new lithosphere, added to each plate. The upper part of the lithosphere is the **crust.** See Figure 2.

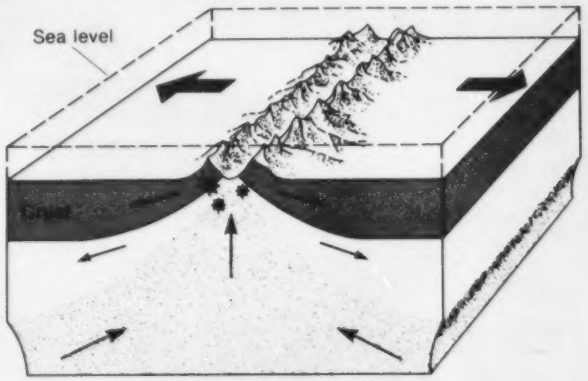


Figure 2. Plates move apart from one another.

A **convergent plate boundary** exists where two plates move toward one another. Converging plates that carry continents will produce mountain ranges, like the Alps and Himalaya Mountains, when the continents collide (Figure 3a). At a convergent plate boundary one plate slides under another; a plate with oceanic crust (more dense) will slide under a plate with continental crust (less dense). See Figure 3b. Notice that lithosphere is destroyed as part of a plate descends into the weak shell (asthenosphere—see Figure 1).

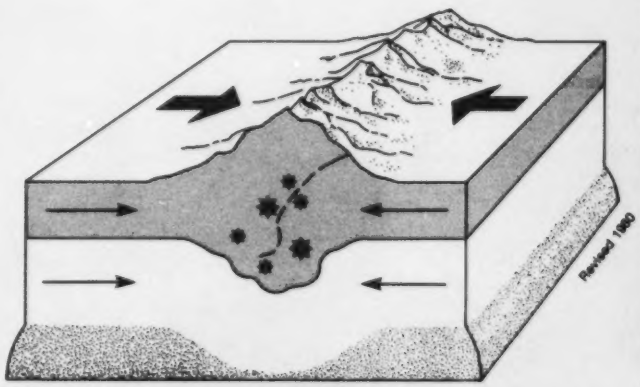
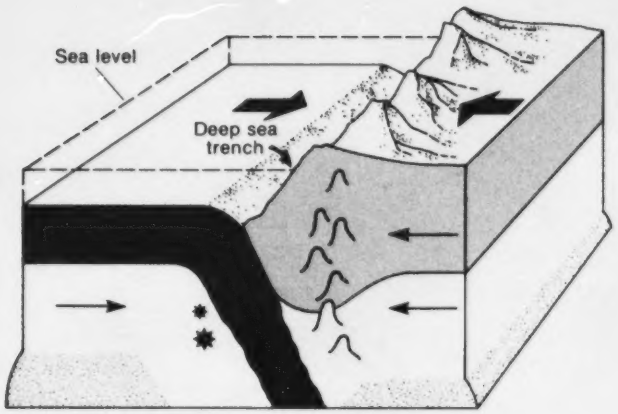


Figure 3a. Where two plates each carrying a continent converge, the continents will eventually collide.



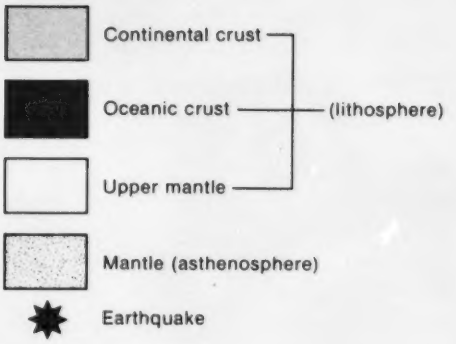


Illustration Key

Figure 3b. A plate with oceanic crust may descend under a plate with continental crust.

A third type of plate boundary is a **transform plate boundary.** This occurs where two plates slide past each other. No lithosphere is formed here and none is destroyed. See Figure 4.

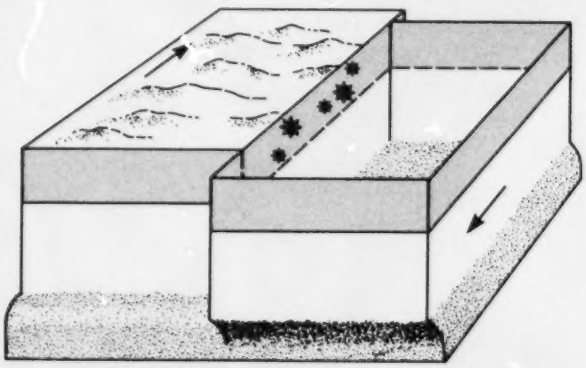


Figure 4. Plates may move past one another.

In this activity you will observe the relationship between plate boundaries as you rotate a rigid plate on a sphere.

PREREQUISITE STUDENT BACKGROUND

This activity is an introduction to the three types of plate boundaries. No background knowledge about lithospheric plate boundaries is necessary and none is assumed.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Identify divergent, convergent, and transform plate boundaries.

2. Demonstrate the relationship between plate boundaries on a sphere by rotating a small piece of the sphere.

3. Determine where earthquakes commonly occur along plate boundaries.

MATERIALS

World Seismicity Map, **United States Geological Survey, 1200 S. Eads Street, Arlington, VA. 22202—at least two copies per class (optional). Wall map, *Pacific Ocean Floor,* National Geographic Society, Educational Services, Department 79, Washington, D.C. 20036—at least two copies per class (optional).**

Plate boundary models—one for each student or team of two. Once the plate boundary models have been made, they can be reused for succeeding classes.

Materials needed for each model:

1 plastic hollow ball about 5-12 cm in diameter; as thin-walled as possible.

1 metal brad, push pin, thumb tack, or paper fastener.

1 celluloid or heavy cardboard tab about 2 or 3 cm wide and as long as diameter of ball.

To construct the model, cut a section out of the ball with a sharp knife. See Figure 5. Attach this section to the tab with a staple or two. Then punch a hole in the ball and attach the other end of the celluloid tab to the ball with the brad or push pin so that the section which was cut out will fit neatly in the area of the ball from which it was cut. Letter the ball as shown in Figure 5.

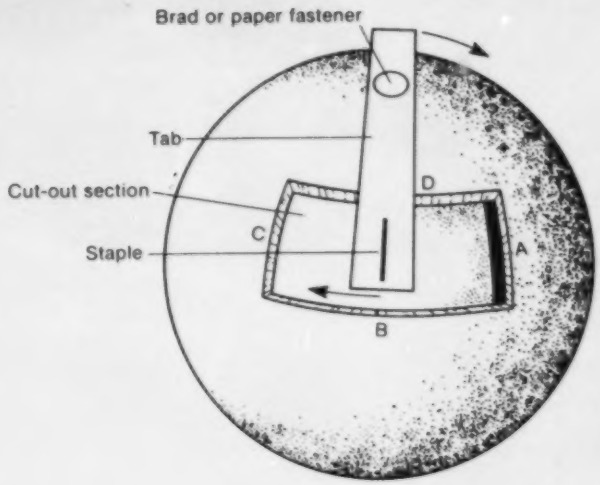


Figure 5. Plate boundary model.

BACKGROUND INFORMATION

The plate tectonics theory states that the outer shell (lithosphere) of the earth is composed of about 7 major plates which move in relation to one another. These plates are assumed to be nearly rigid horizontally.

Interactions at plate boundaries explain the distribution of many large scale geological features and zones of activity—narrow belts of mountains, volcanic and seismic activity.

The major purpose of this activity is to introduce the student to three types of plate boundaries: divergent, convergent and transform.

It is often difficult to grasp spatial relationships when presented in two dimensions. In order to provide concrete examples of plate boundaries, this activity requires the student to move a simulated plate on a sphere.

SUGGESTED APPROACH

This activity is designed for students working individually or in pairs, depending on class size and the number of plate boundary models available. A group discussion of results would be beneficial.

Particularly useful are the EXTENSIONS where students are asked to compare the model to real plate boundaries on the *Pacific Ocean Floor* map.

REFERENCES

Cox, A., 1973, *Plate tectonics and geomagnetic reversals.* San Francisco, W.H. Freeman and Company, p. 40-47.

Wyllie, P.J., 1976, *The way the earth works.* New York, John Wiley and Sons, Inc., p. 61-72.

PROCEDURE

In this activity each student will compare descriptions of plate boundaries discussed in the INTRODUCTION to boundaries on the crustal plate boundary model.

Key words: divergent plate boundary, convergent plate boundary, transform plate boundary, lithosphere, plates (plates of the asthenosphere), crust

Time required: one to two 45-minute periods

Materials: plate boundary model, *World Seismicity Map, Pacific Ocean Floor* map.

Take the plate boundary model like the one shown in Figure 5 and move the small plate clockwise. The small plate will move in relation to the large plate (sphere). Be sure to slide the small plate under the large plate.

1. At which letter did the small plate shorten and slide under the big plate?

Boundary C

2. What kind of plate boundary is this?

Convergent plate boundary

3. At which letter did the small plate spread apart from the big plate?

Boundary A

4. What is the name of this kind of plate boundary?

Divergent plate boundary

5. At which letter does new lithosphere form?

Boundary A

6. At which letter is lithosphere destroyed?

Boundary C

7. Where are the boundaries between the small plate and the big plate where the crust is conserved...that is, where lithospheric plates are not destroyed or new material added?

Both boundaries B and D

8. Which plate boundaries are parallel to the direction of plate motion?

Both boundaries B and D

9. If you lived in the middle of the big plate or the small plate, would you feel the small plate move?

No motion would be felt. It is a problem of scale. The Pacific Plate, for example, is moving northward (relative motion) at about 3 cm per year and is not felt unless the motion occurs in jerks, as during an earthquake. Even then the motions will be felt nearer the epicenter of the earthquake.

10. If you lived on a plate boundary, would you feel the plate move? Why or why not?

Since earthquakes occur predominantly on plate boundaries people living nearest the plate boundaries would feel the earthquake (hence feel plate motion).

SUMMARY QUESTIONS

1. Where do earthquakes commonly occur?

Earthquakes commonly occur along plate boundaries.

2. Explain the three types of plate boundaries.

Divergent plate boundary: **plates moving apart from one another. This creates new crust.**

Convergent plate boundary: **one plate slides under another. Continents on converging plates may collide with one another. This may form mountain ranges; or, one plate may slide under another, resulting in destruction of crust.**

Transform plate boundary: **plates sliding past one another. No crust is formed and none is destroyed.**

EXTENSIONS

1. Compare the plate boundary model to the *Pacific Ocean Floor* map. Locate on the map each of the kinds of plate boundaries you have studied.

Convergent plate boundaries can be identified along the margin of the Pacific Ocean (Japan, Chile/Peru, Alaska, etc.).

Divergent plate boundaries are located along the East Pacific Rise and the Southeast Indian Ocean Ridge.

A transform plate boundary is located in California and is expressed as the San Andreas Fault.

2. Compare the plate boundary model to the *World Seismicity Map*. Do most of the earthquakes occur along plate boundaries? (Hint: Compare Figures 2, 3a, 3b, and 4 to the map.) Are the depths of earthquakes different along different kinds of plate boundaries?

The point of this question is to note the relationship of earthquakes to plate boundaries. Students should note that earthquake depth increases in the direction that the plate is descending under the continent (Figure 3b in this module). Examine converging plate boundary near Chile or the boundaries north of New Zealand on the *World Seismicity Map*.

NAGT Crustal Evolution Education Project Modules

CEEP Modules are listed here in alphabetical order. Each Module is designed for use in the number of class periods indicated. For suggested sequences of CEEP Modules to cover specific topics and for correlation of CEEP Modules to standard earth science textbooks, consult Ward's descriptive literature on CEEP. The Catalog Numbers shown here refer to the CLASS PACK of each Module consisting of a Teacher's Guide and 30 copies of the Student Investigation. See Ward's descriptive literature for alternate order quantities.

CEEP Module	Class Periods	CLASS PACK Catalog No.
• A Sea-floor Mystery: Mapping Polarity Reversals	3	34 W 1201
• Continents And Ocean Basins: Floaters And Sinkers	3-5	34 W 1202
• Crustal Movement: A Major Force In Evolution	2-3	34 W 1203
• Deep Sea Trenches And Radioactive Waste	1	34 W 1204
• Drifting Continents And Magnetic Fields	3	34 W 1205
• Drifting Continents And Wandering Poles	4	34 W 1206
• Earthquakes And Plate Boundaries	2	34 W 1207
• Fossils As Clues To Ancient Continents	2-3	34 W 1208
• Hot Spots In The Earth's Crust	3	34 W 1209
• How Do Continents Split Apart?	2	34 W 1210
• How Do Scientists Decide Which Is The Better Theory?	2	34 W 1211
• How Does Heat Flow Vary In The Ocean Floor?	2	34 W 1212
• How Fast Is The Ocean Floor Moving?	2-3	34 W 1213
• Iceland: The Case Of The Splitting Personality	3	34 W 1214
• Imaginary Continents: A Geological Puzzle	2	34 W 1215
• Introduction To Lithospheric Plate Boundaries	1-2	34 W 1216
• Lithospheric Plates And Ocean Basin Topography	2	34 W 1217
• Locating Active Plate Boundaries By Earthquake Data	2-3	34 W 1218
• Measuring Continental Drift: The Laser Ranging Experiment	2	34 W 1219
• Microfossils, Sediments And Sea-floor Spreading	4	34 W 1220
• Movement Of The Pacific Ocean Floor	2	34 W 1221
• Plate Boundaries And Earthquake Predictions	2	34 W 1222
• Plotting The Shape Of The Ocean Floor	2-3	34 W 1223
• Quake Estate (board game)	3	34 W 1224
• Spreading Sea Floors And Fractured Ridges	2	34 W 1225
• The Rise And Fall Of The Bering Land Bridge	2	34 W 1227
• Tropics In Antarctica?	2	34 W 1228
• Volcanoes: Where And Why?	2	34 W 1229
• What Happens When Continents Collide?	2	34 W 1230
• When A Piece Of A Continent Breaks Off	2	34 W 1231
• Which Way Is North?	3	34 W 1232
• Why Does Sea Level Change?	2-3	34 W 1233

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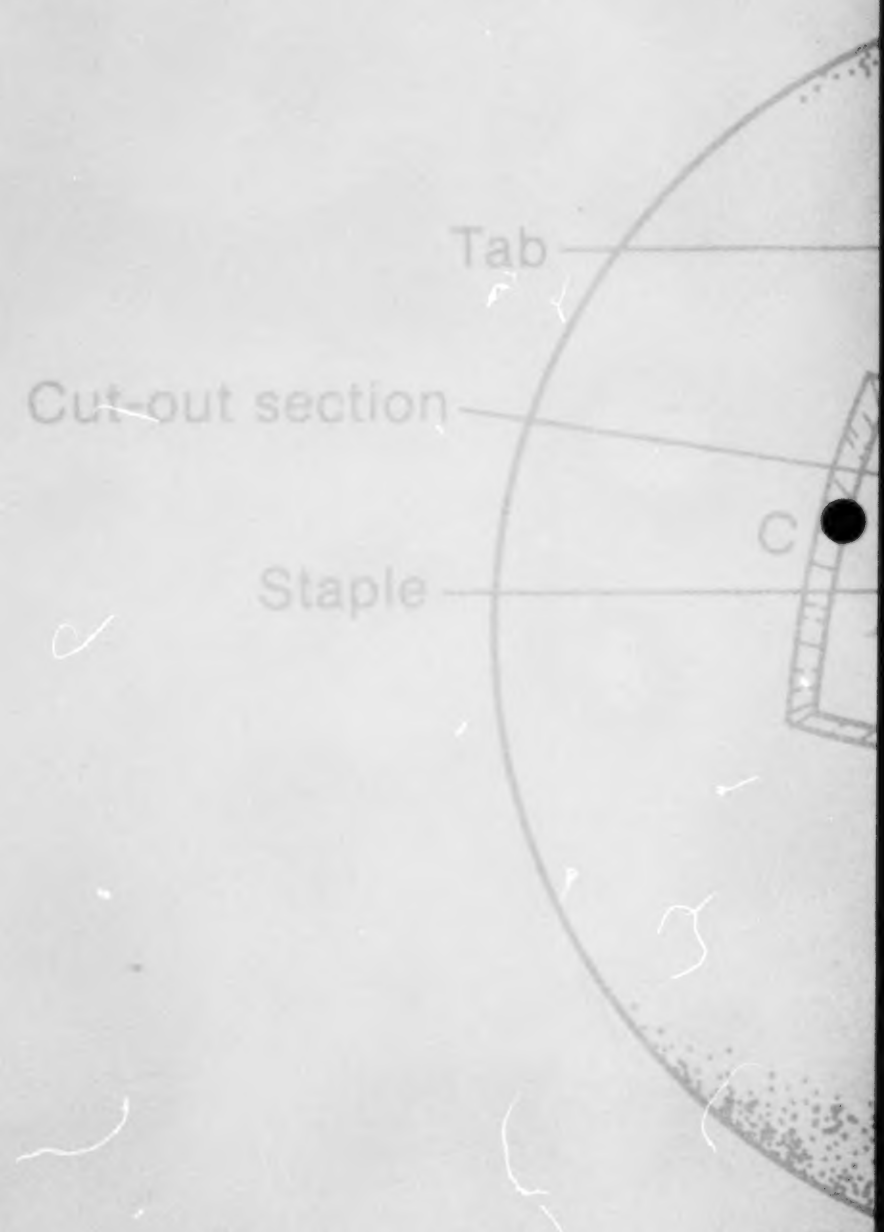

WARD'S
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CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

Student Investigation

Catalog No. 34W1116

Introduction To Lithospheric Plate Boundaries

INTRODUCTION

The earth's **lithosphere** is composed of semi-rigid **plates** that move in different directions. A great deal of action takes place along boundaries between plates. Most earthquakes are located there. Figure 1 shows the relation of these plates and the outer shells of the earth.

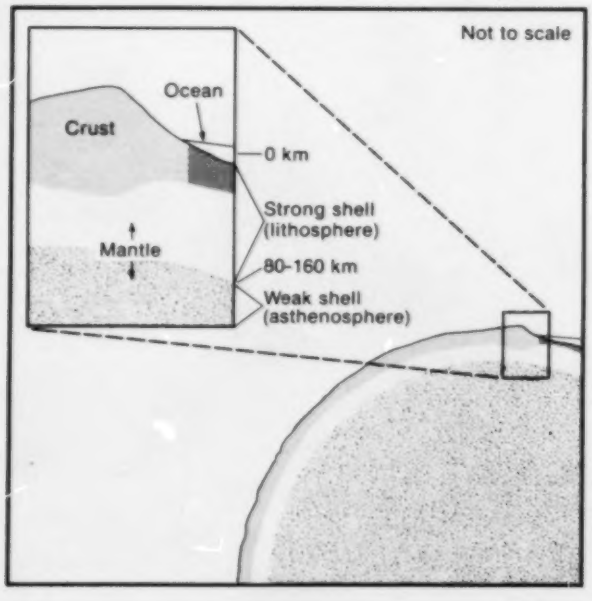

Figure 1. Diagram showing the rigid lithospheric plates and their relationship to the outer shells of the earth (not to scale).

Plates move away from each other along a **divergent plate boundary.** As the plates move apart, material from the **asthenosphere** fills the gap. This creates new lithosphere, added to each plate. The upper part of the lithosphere is the **crust.** See Figure 2.

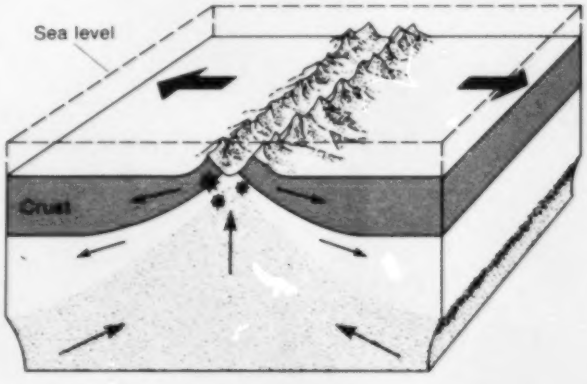

Figure 2. Plates move apart from one another.

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A **convergent plate boundary** exists where two plates move toward one another. Converging plates that carry continents will produce mountain ranges, like the Alps and Himalaya Mountains, when the continents collide (Figure 3a). At a convergent plate boundary one plate slides under another; a plate with oceanic crust (more dense) will slide under a plate with continental crust (less dense). See Figure 3b. Notice that lithosphere is destroyed as part of a plate descends into the weak shell (asthenosphere—see Figure 1).

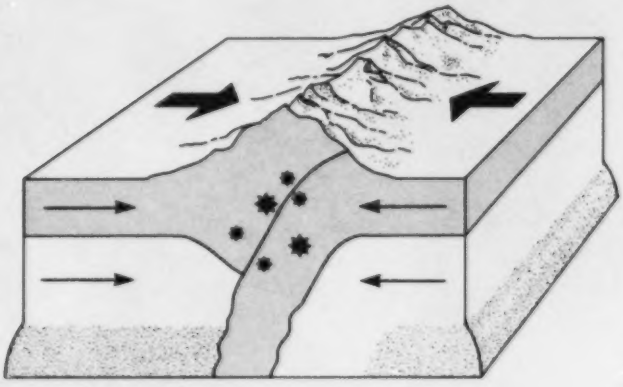

Figure 3a. Where two plates each carrying a continent converge, the continents will eventually collide.

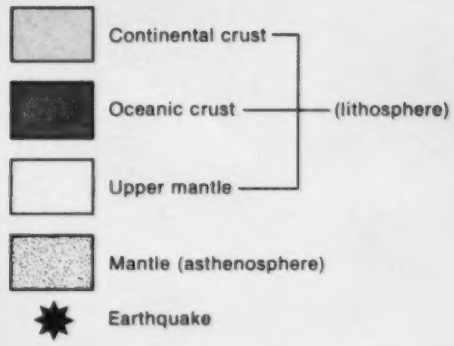

Illustration Key

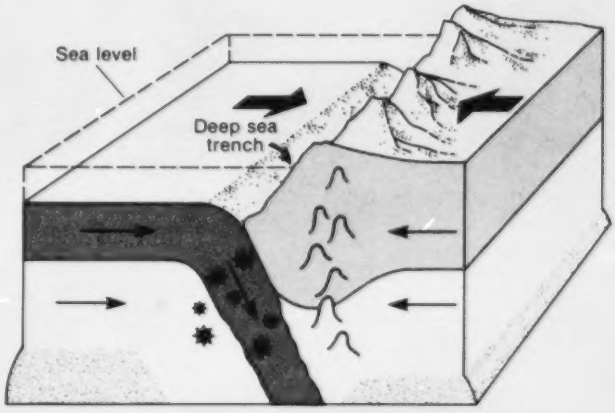

Figure 3b. A plate with oceanic crust may descend under a plate with continental crust.

A third type of plate boundary is a **transform plate boundary.** This occurs where two plates slide past each other. No lithosphere is formed here and none is destroyed. See Figure 4.

In this activity you will observe the relationship between plate boundaries as you rotate a rigid plate on a sphere.

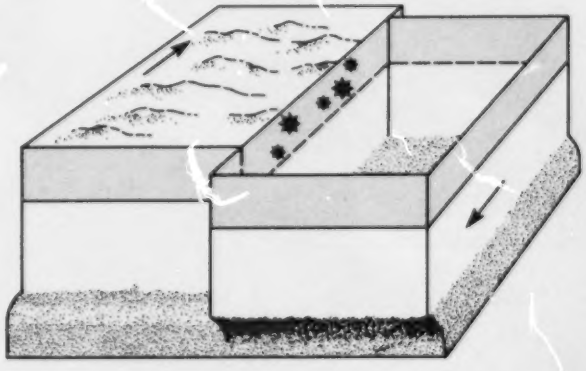

Figure 4. Plates may move past one another.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Identify divergent, convergent, and transform plate boundaries.
2. Demonstrate the relationship between plate boundaries on a sphere by rotating a small piece of the sphere.
3. Determine where earthquakes commonly occur along plate boundaries.

PROCEDURE

Materials: plate boundary model, *World Seismicity Map, Pacific Ocean Floor* map.

Take the plate boundary model like the one shown in Figure 5 and move the small plate clockwise. The small plate will move in relation to the large plate (sphere). Be sure to slide the small plate under the large plate.

1. At which letter did the small plate shorten and slide under the big plate?

2. What kind of plate boundary is this?

3. At which letter did the small plate spread apart from the big plate?

4. What is the name of this kind of plate boundary?

5. At which letter does new lithosphere form?

6. At which letter is lithosphere destroyed?

7. Where are the boundaries between the small plate and the big plate where the crust is conserved...that is, where lithospheric plates are not destroyed or new material added?

8. Which plate boundaries are parallel to the direction of plate motion?

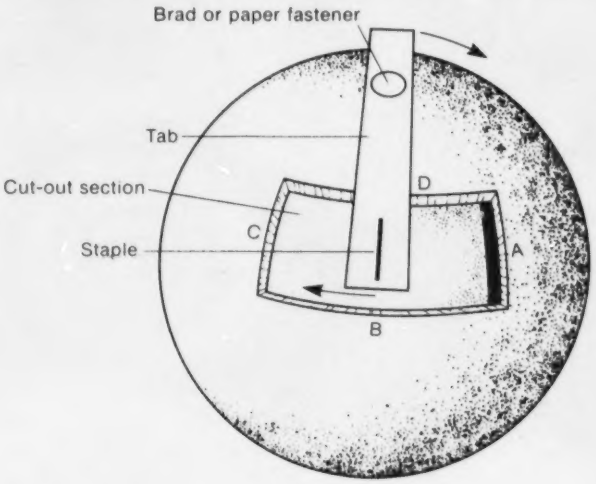

Figure 5. Plate boundary model.

9. If you lived in the middle of the big plate or the small plate, would you feel the small plate move?

10. If you lived on a plate boundary, would you feel the plate move? Why or why not?

SUMMARY QUESTIONS

1. Where do earthquakes commonly occur?

2. Explain the three types of plate boundaries.
Divergent plate boundary:

Convergent plate boundary:

Transform plate boundary:

EXTENSIONS

1. Compare the plate boundary model to the *Pacific Ocean Floor* map. Locate on the map each of the kinds of plate boundaries you have studied.

2. Compare the plate boundary model to the *World Seismicity Map*. Do most of the earthquakes occur along plate boundaries? (Hint: Compare Figures 2, 3a, 3b, and 4 to the map.) Are the depths of earthquakes different along different kinds of plate boundaries?

REFERENCES

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